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Forest Insect Laboratory
Berkeley, California
July 20, 1937

TUSOCK MOTH, *HEMEROCAMPA OSLARI*:
PRELIMINARY EXAMINATION OF INFESTED AREAS
ON THE INYO AND MONO NATIONAL FORESTS, CALIFORNIA,
JUNE 23-25, 1937

by

J. E. Patterson

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AREAS ON THE INYO AND MONO NATIONAL FORESTS, CALIFORNIA, JUNE 23-25, 1937

APPROVED BY:

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J. E. PATTERSON
Associate Entomologist

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The data concerning the present year's infestation were secured by a brief examination of the areas made June 23-25. Before discussing them, a summary of the results of previous observations will be given.

HISTORY OF THE PRESENT EPIDEMIC.

First reports of the present epidemic are contained in notes made by Donald DeLeon who visited the Mammoth area in company with S. T. Carlson on August 18, 1936. He found the nucleus of this infestation centered on the fir covered slopes of Hess Mill Hill, about three miles north of the Mammoth R. S. He estimated the extent of the defoliated area at about 4 sections, and states "The tops and upper crowns (of the fir) chiefly attacked. Such trees have fire scorched appearance. Caterpillars spinning cocoons and pupating. There appeared to be more 1936 cocoons than 1935 cocoons, which indicates, perhaps, an increase --- Besides white fir caterpillars feed on Jeffrey pine but such feeding was not extensive, and although cocoons form on Jeffrey pine, could not tell whether caterpillars had developed entirely on this host.

A second report was contained in a letter written on December 9, 1936 by Supervisor Roy Boothe to J. M. Miller. Boothe states "While making an inspection trip in the Mammoth District yesterday we noticed that nearly 100 per cent mill is being made in white fir by some sort of needle parasite. This newest infested area is located on the Hess Mill cut-off road about 1 1/2 miles north of the sawmill. There is perhaps 40 acres or more involved in that particular area".

Undoubtedly both DeLeon and Boothe examined the same area and their notes refer to that particular infestation center, and where I found the most recent activity in June 1937.

Earlier infestations of the tussock moth have been brought to the attention of the Bureau of Entomology. Mr. J. M. Miller reported a destructive epidemic of this moth in fir in the year 1906 on the west side of the Sierras in the Sierra National Forest. H. H. Simpson of the Inyo reported that defoliation of fir occurred about this time in the east side areas. These reports indicate an interval of approximately 30 years between epidemics.

DISTRIBUTION OF PRESENT EPIDEMIC.

The examination made in June 1937 extended the known defoliated areas throughout the region from Convict Creek on the Inyo to Silver Lake on the Mono. The center of defoliation is still on the Hess Mill Hill. This latter covers an area of approximately 800 acres. The range of recent defoliation includes several distinct areas where epidemic conditions have prevailed. These areas are confined to stands where the white fir is the dominant species. That these areas do not coalesce is due to breaks in the fir type. Epidemic conditions have also been pronounced on an area of 400 acres on the north exposure between Convict Creek and Mammoth R. S.; on the east slope two miles north of Casa Diablo, 80 acres; two miles southeast of Big Springs near the Thompson ranch, 200 acres; west of the highway between Deadman and Glass Creeks, 200 acres; and on an area of 250 acres near Gull Lake in the Reversed Creek section of the Mono. Observations in these centers were concerned principally with the degree and extent of defoliation of individual trees and the resultant damage. Loss of foliage of the same year's growth on separate trees indicates that the inception of infestations on individual areas occurred simultaneously throughout the present range. However, the amount of damage is distinctly greater on some areas than on others. The percentage of killed trees is by far greater on the two most southern areas, (Mammoth and Casa Diablo) which would indicate a higher concentration of caterpillars during the height of feeding activity.

HOST AND DAMAGE:

White fir (Abies concolor) is the favored and natural host although the caterpillars feed sparingly on Jeffrey pine when it occurs in mixture with white fir. Cocoons are also spun on this species but it is not known whether the caterpillars forming them had fed exclusively on this host or had partially developed on white fir. So far as observations to date reveal no other species are hosts. Many red fir (Abies magnifica) trees occur in the defoliated areas though no feeding could be detected upon them. Lodgepole pine is likewise immune to attack.

The damage to the host can be extensive and severe, resulting in death of the entire tree when defoliation is complete. The usual damage, however, consists of partial to complete defoliation of the middle and upper crown, which results in the suppression of growth or death of the main terminal and lateral branches. Many spike-top trees are now visible in the defoliated areas. Where defoliations have been severe and repeated annually for three or four years, as they have evidently been on some areas, death of many trees has resulted. At least 70% of the trees in the epidemic areas, Mammoth and Casa Diablo, are now dead. These dead trees range in size from saplings to the largest specimens up to 30" in diameter.

There is evidence that epidemic infestations have persisted on these two areas for at least three years. Even though infested trees escape death their vitality must be greatly lowered and growth suppressed by the loss of their needles. Measurement of the annual increment will be made later in the season in order to determine the degree of suppression effected. Defoliation of Jeffrey pine has not been severe in any observed case, and no trees of this species are known to have died from the insects' attacks.

FEEDING HABITS:

Feeding of newly hatched caterpillars begins late in June when the current needle growth is well advanced. Captive caterpillars feed indiscriminately on the new growth as well as on needles of previous years. It is not known if this habit is normal in the field although the stripped condition of defoliated branches indicates that it is. In newly developed infestations the caterpillars select the upper crowns and the first attacks are made on this portion of the trees. Later, as the epidemic gains in intensity, and as hordes of caterpillars infest each tree in an invaded area, they take needles lower down and eventually strip the entire tree. The insect completes its life cycle in one year and the feeding period extends normally from June 1-15 to August 15-20, of each year.

PUPATION:

Pupae are formed in cocoons which are spun up on the lower sides of branches; on the tips of secondary twigs; and sparingly on the lower trunks of trees. Cocoons were found in the areas examined on both white fir and Jeffrey pine. The cocoons are densely covered with body hairs from the caterpillars. These hairs contain a toxic substance which causes extreme irritation to the skin and may protect the pupae from being eaten by birds and rodents. Normally from 3 to 6 cocoons are found matted together in one mass.

EMERGENCE:

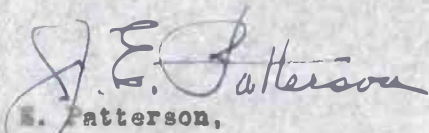
Adult moths emerge during the first half of September. The males are winged and are strong fliers. The females are wingless. The duration of the flight period as well as the longevity of the adults is unknown.

EGGS:

The eggs are deposited in masses and are firmly attached to the support, usually among cocoons on the twigs or on the bole of the tree. However, egg masses are found on debris near the base of trees. The incubation period is prolonged, lasting throughout the winter and spring months.

This memorandum summarizes the present stock of information on this moth in the region studied. Many facts concerning the biology of the species have yet to be secured. Further study is essential to complete our present knowledge of its life history, habits, and economic importance as a periodic pest. Further study of the present epidemic is planned and it is hoped that many points now obscure will be cleared up.

Berkeley, California.
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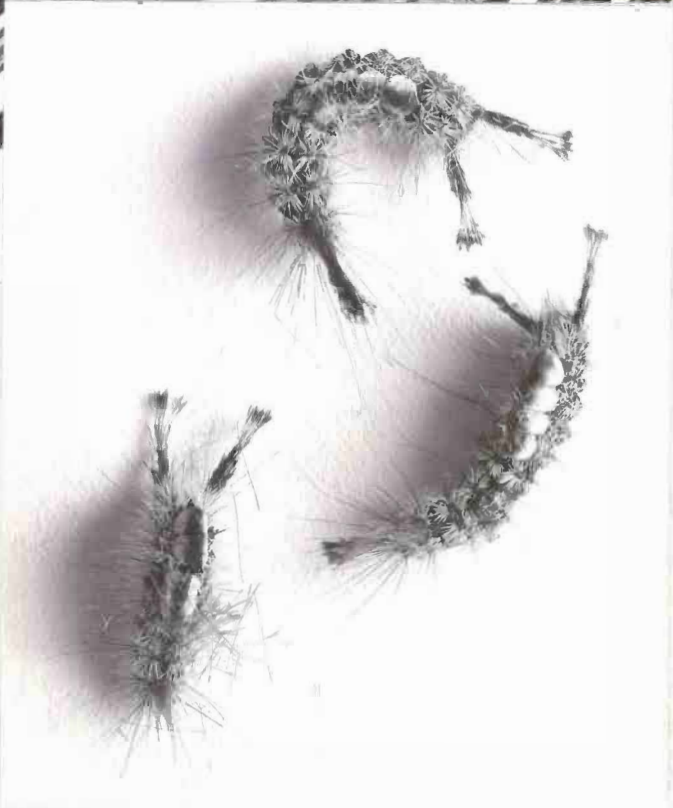

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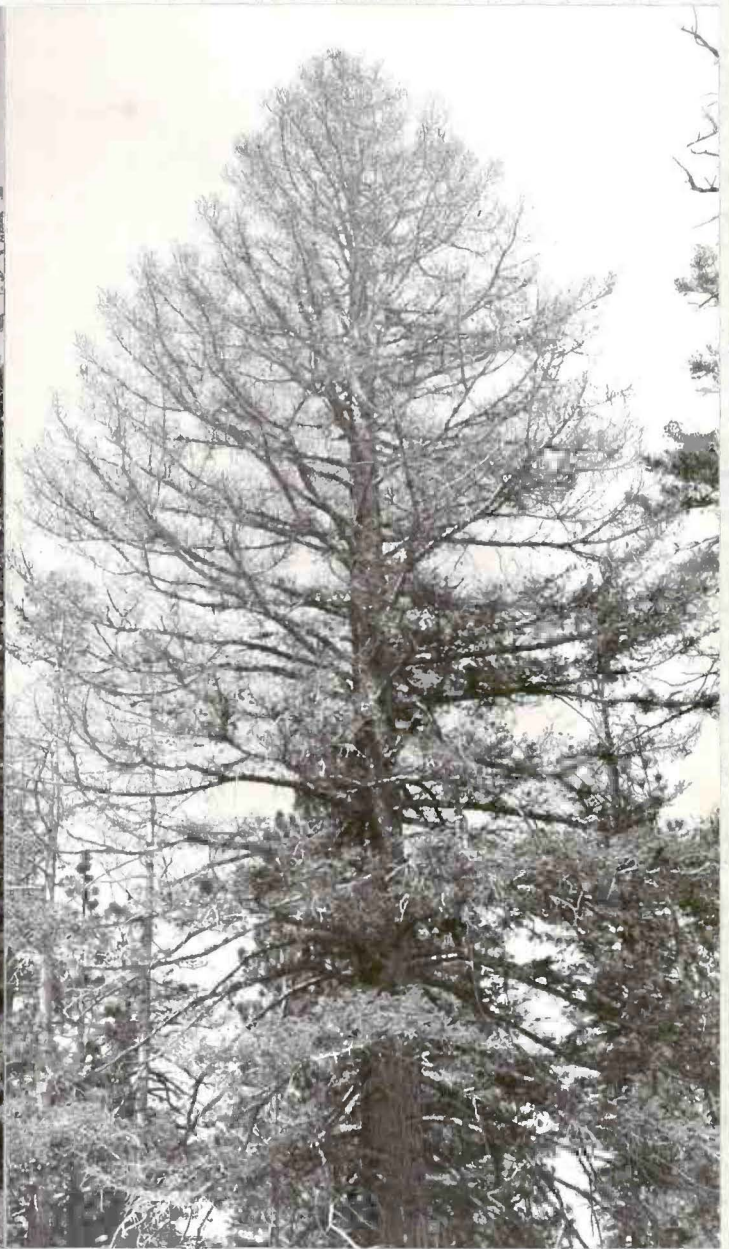
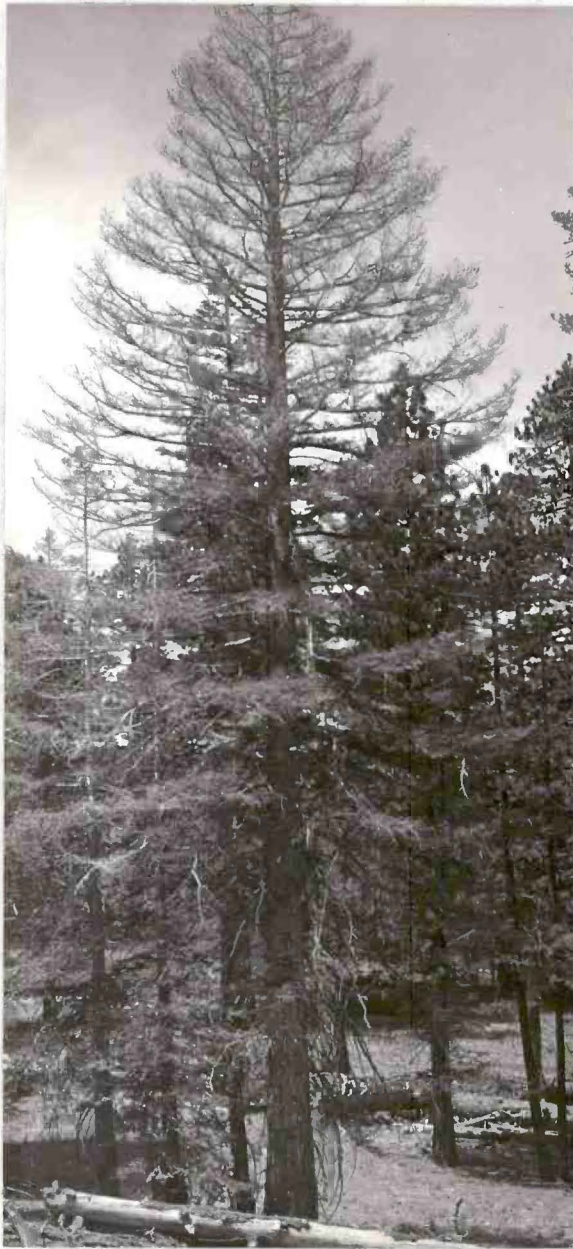


9931A - Many young white fir trees are defoliated only at the extreme top. When such defoliation is severe, as in this case, the tops die, and if the tree survives a lateral terminal is put out.

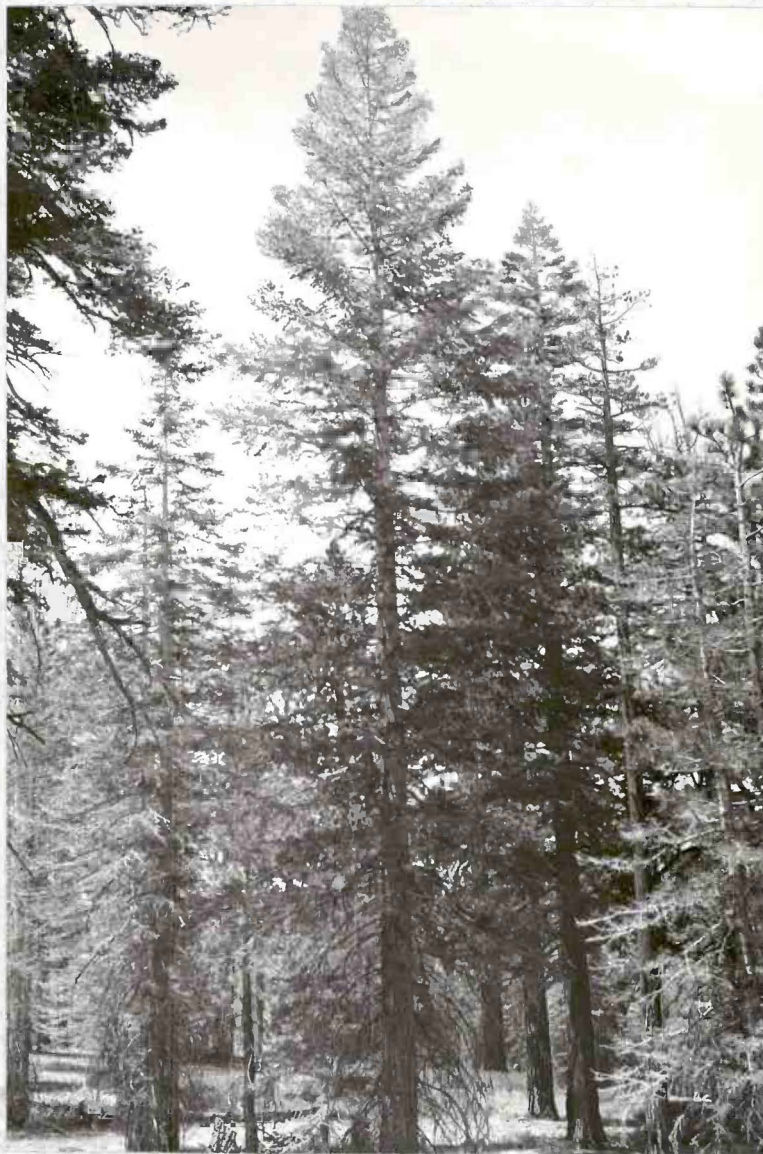


9937 - Full grown caterpillars
of Osler's tussock moth. Cater-
pillars of the last instar just
before pupation. Above: on white
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larged about 2X.





9931B - 9931C - Severe defoliations of mature white fir characteristic of epidemic centers of infestation. Tree at left is completely stripped of needles and has small chance of recovery. Only the upper crown of the tree at the right is stripped. This tree may survive as a spike top.



9931b - Partial defoliation of the upper crown of a vigorous, middle aged, white fir tree. Such examples will recover if defoliation is not continued.

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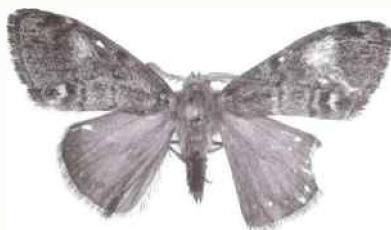
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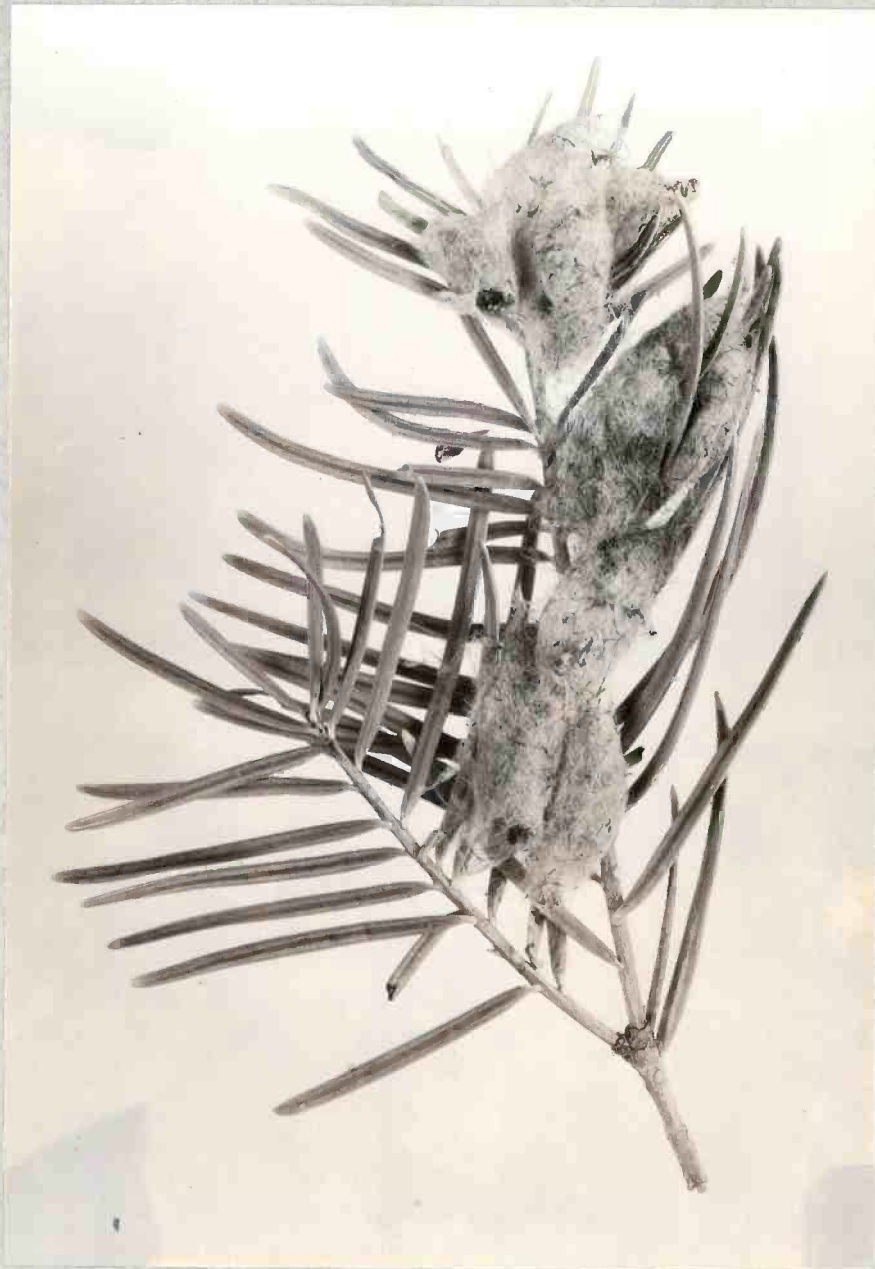


9926A



9926B

Adult male and female tussock moths, Hemerocampa oslari.
(Barnes). Photographs of pinned specimens, enlarged
1 2/3 times.



10027F

Cocoons of Oslar & Tussock moth attached to the tip of white fir twig. These are empty cocoons; the moths having already emerged.



10027E

Cocoons attached to terminal shoot of Jeffrey pine. The caterpillars feed sparingly on this species, although white fir is the preferred host. Note partial defoliation of this specimen.



10027D

The result of heavy feeding on a white fir tip. This is a typical example of maximum defoliation found in the centers where infestations have persisted for two and three years. Trees suffering this amount of defoliation reflect the damage in the dwarfed appearance of the recent needle growth.



10027A

Appearance of defoliated white fir in an area where the infestation has been epidemic for a period of two years. Note the sparse crowns of the mature trees and defoliation of the younger stock.



10027B

A typical example of a severely defoliated young white fir tree. The lower branches of this tree supported 227 cocoons of the tussock moth.



100270

View of the defoliated center near Casa Diablo where the infestation has been epidemic for a period of three years. About 70% of the affected trees on this area have died as a result of defoliation.

area - Same - Home birds for 1937

Spine - develop exclusively, in this species but develop light
due to long needles -

Seasonal history -

Development of the 1937 brood

Habit: eggs laid in middle crown -

young catfish feeding same place

Cats on grass and overhanging trees

~~Many~~

Enemies - West disease

Parasites -

Squirrels & birds don't touch

Damage -

Tree striped squirrels -

Ring measurements.

from hatching to pupation; but due to the extra long, heavy, needles ~~the~~ the resultant damage is not severe and does not ~~seriously~~ damage the trees, to the extent that white fir suffers from these associations.

The 1937 brood of caterpillars was heavier than previous broods developed - this present epidemic. In late July the caterpillars were 25 mm in length and nearly full grown. They covered the trees from the lowest limbs to the tip. However, feeding caterpillars tend to concentrate in the upper crown where the greatest amount of feeding is done, and consequent greater defoliation results. This effect is graphically shown in the photographs on page _____. The appearance of many of such trees, where all the needles have been stripped from the entire upper crown, is such that recovery seems impossible. Many other trees defoliated to this extent by broods of the previous two years have died. However, trees suffering light to medium defoliation, as the example shown in the picture on page _____, have a good chance to survive, and ^{is believed} ~~is not repeated~~ to recover from the effects of temporary check

2

Following the preliminary studies made of the Western West
infestations on the Sierra forest were in June and reported
in the first section of this memorandum,

Subsequent observations:

> A second examination of these ^{same} infested areas
on the ~~Sierra~~ forest was made on July 28-29, 1937.

Additional information on the habits of the ~~Western~~
West was obtained and, ~~is given in the following~~
paragraphs:

The 1937 crop of caterpillars

a goodly number of caterpillars were culled
for rearing and study at the Berkeley Laboratory.

The rearing of these caterpillars thru to adult
form was ~~successfully~~ carried out. The following
paragraphs deal specifically with events in
the seasonal history of the 1937 brood but apply
generally to the species in infestations on the
eastern front of the Sierra Divide.

The 1937 brood of caterpillars was confined
to the same areas infested in 1936. It is,
of course, possible that incipient infestations ^{however} of this brood
have appeared in other areas, ~~but~~ ^{open} from
the previously known infested areas was not
confirmed although all the white fir stands
in the region were examined. It was also definitely
confirmed that caterpillars fed ^{entirely} ~~exclusively~~ on ^{this host} ~~Jeffrey pine~~
~~deciduous~~ from eggs laid on Jeffrey pine.

~~defoliation~~ within a short time. Many such
trees defoliated in the early stages of the current
epidemic, and not subsequently attacked, have
recovered and put out new needle growth.



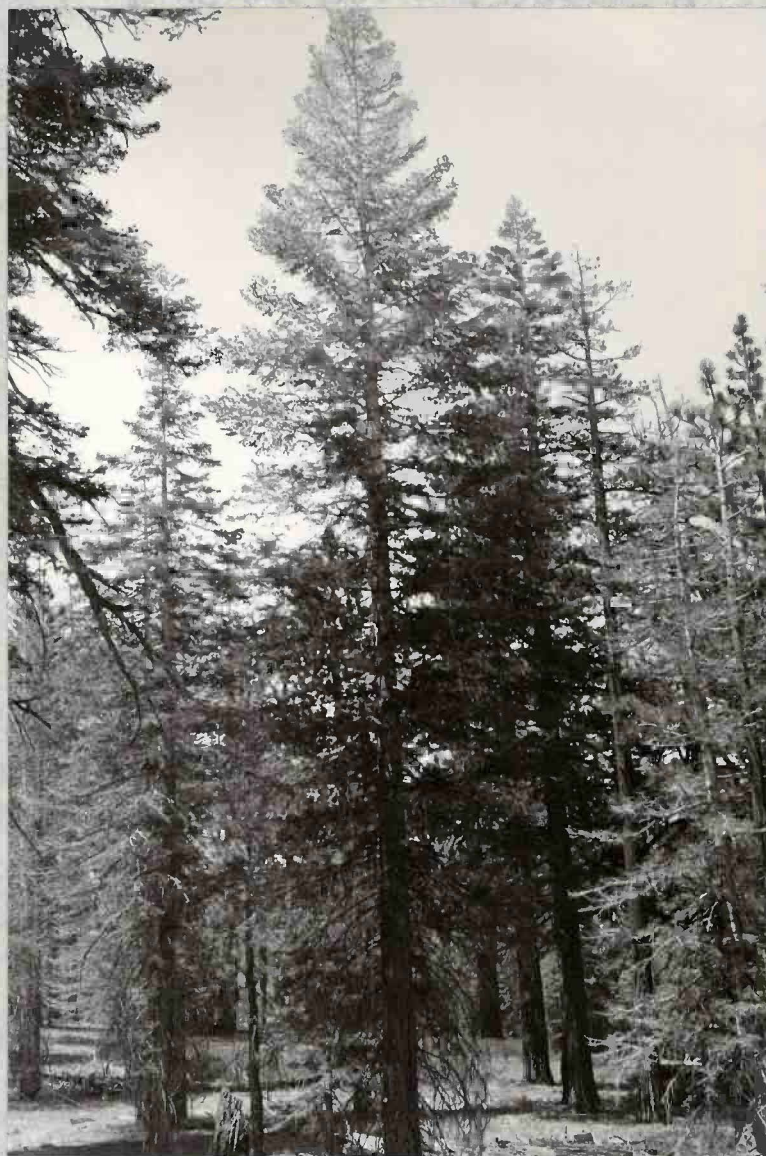
9931A - Many young white fir trees are defoliated only at the extreme top. When such defoliation is severe, as in this case, the tops die, and if the tree survives a lateral terminal is put out.



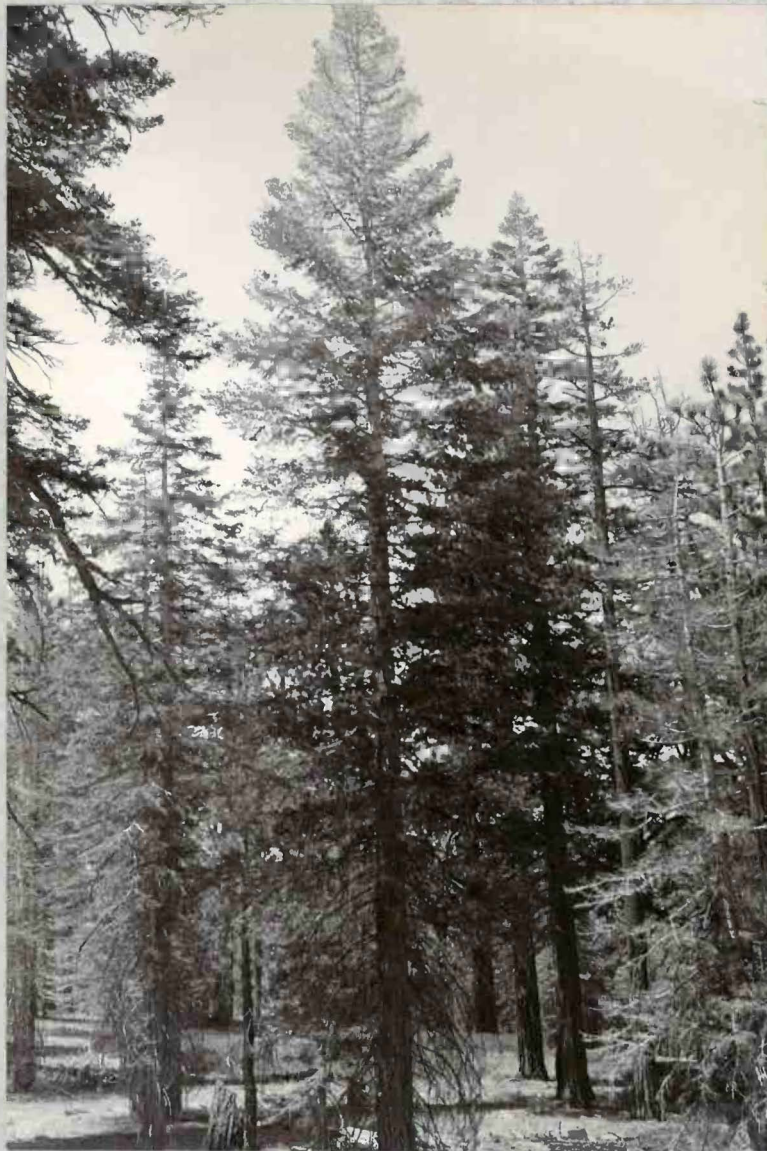
9931B - Partial defoliation of the upper crown of a vigorous, middle aged, white fir tree. Such examples will recover if defoliation is not continued.



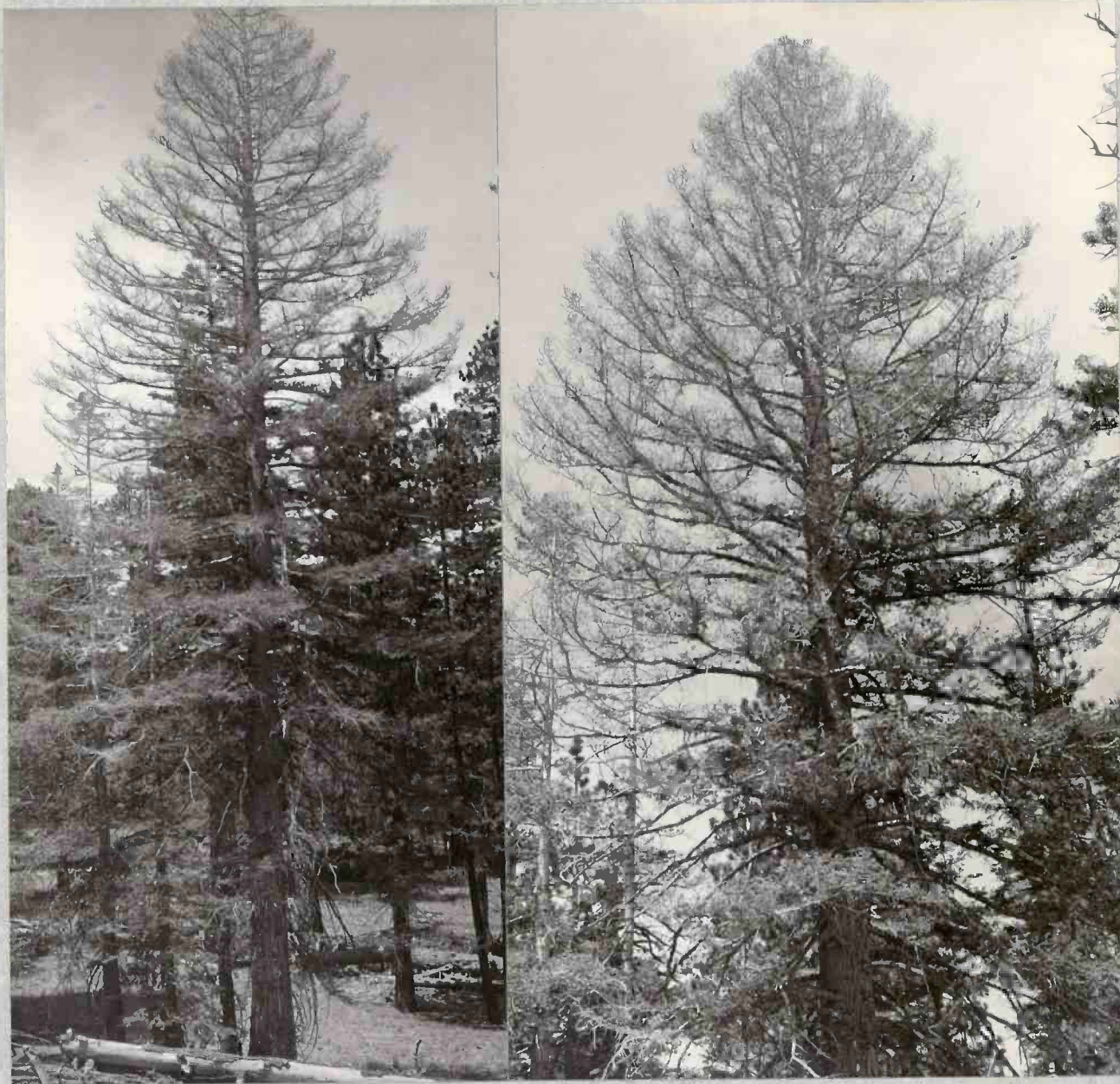
9931D - Partial defoliation of the upper crown of a vigorous, middle aged, white fir tree. Such examples will recover if defoliation is not continued.



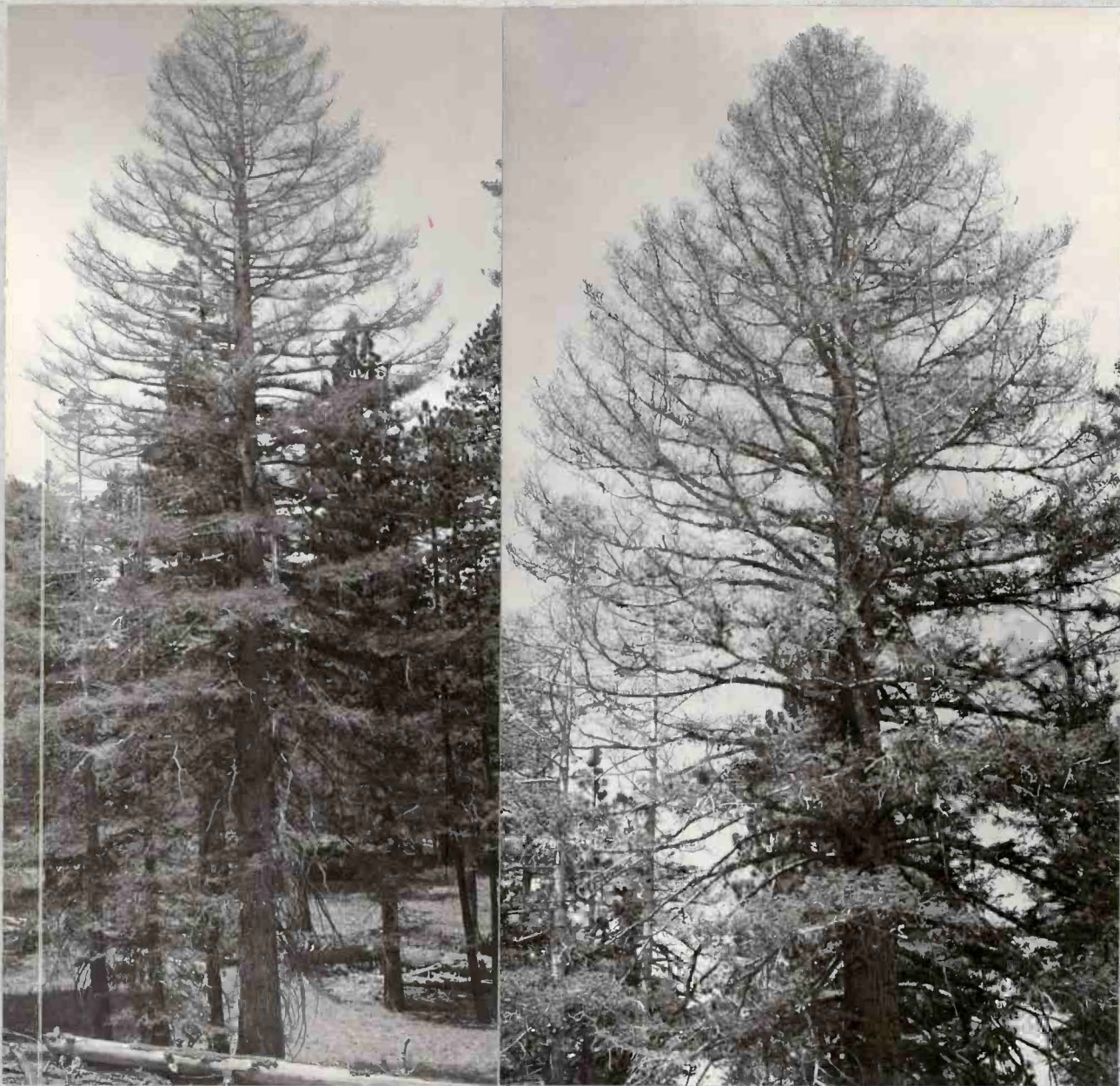
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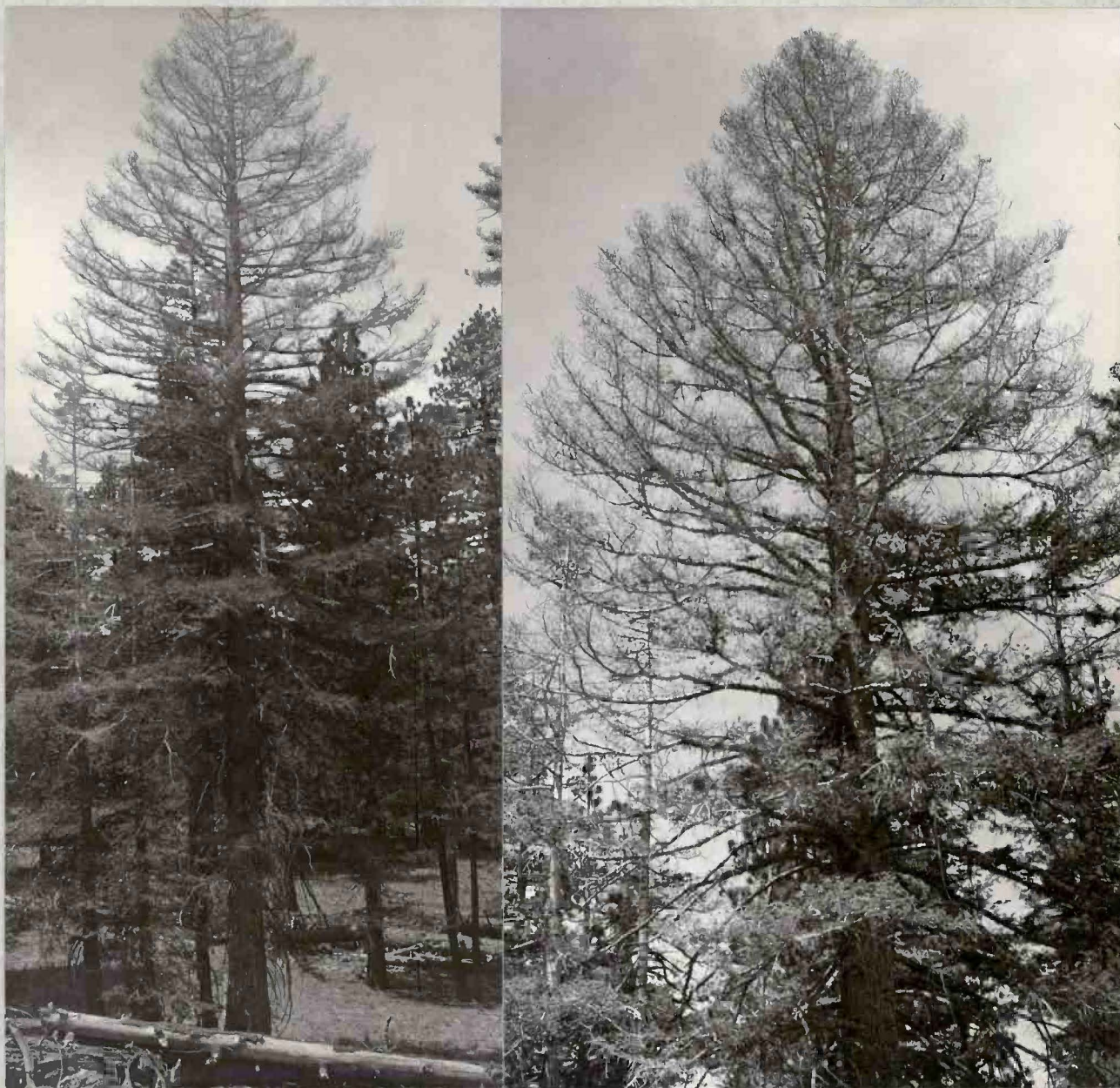
9931B - 9931C - Severe defoliations of mature white fir characteristic of epidemic centers of infestation. Tree at left is completely stripped of needles and has small chance of recovery. Only the upper crown of the tree at the right is stripped. This tree may survive as a spike top.



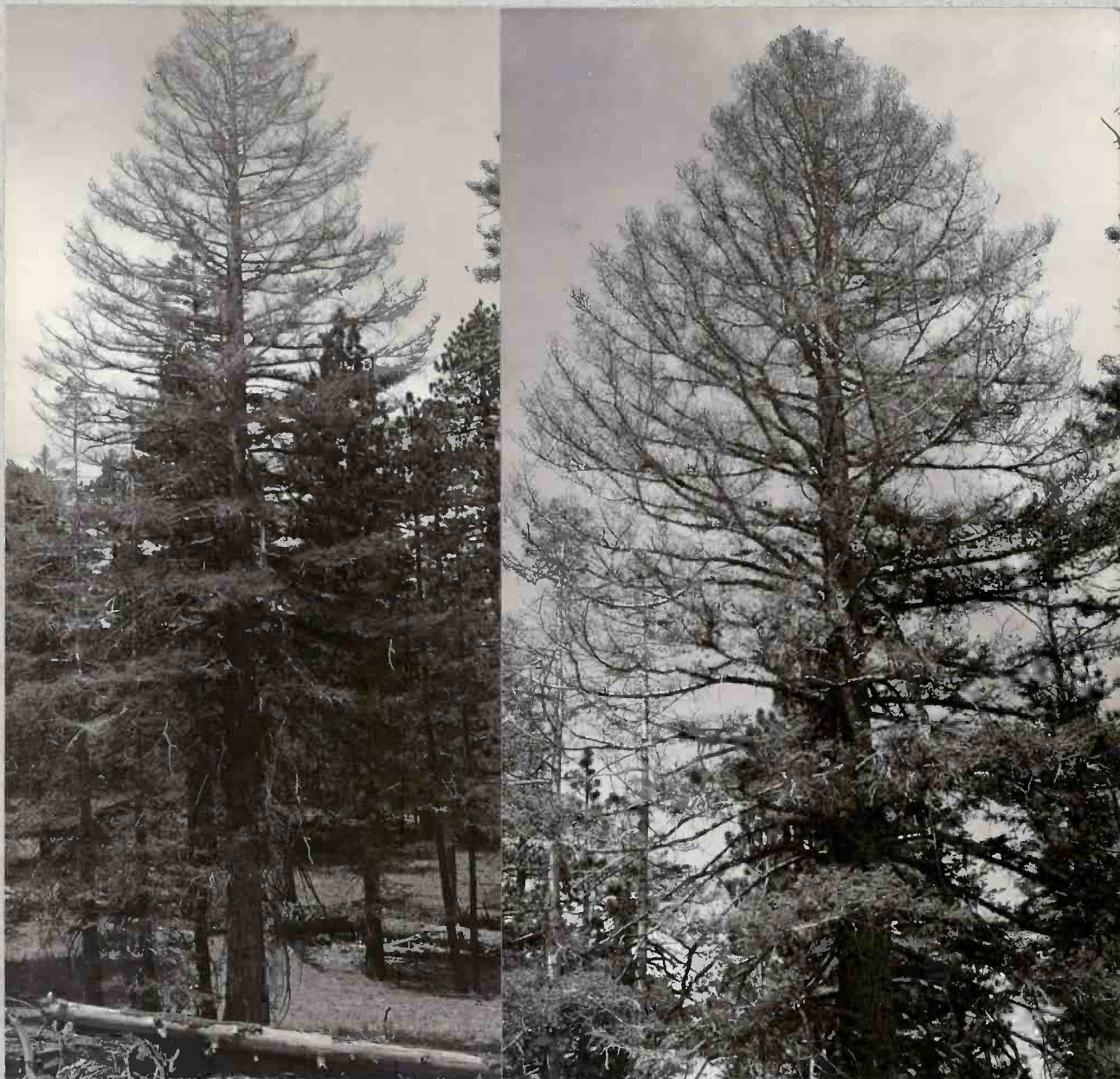
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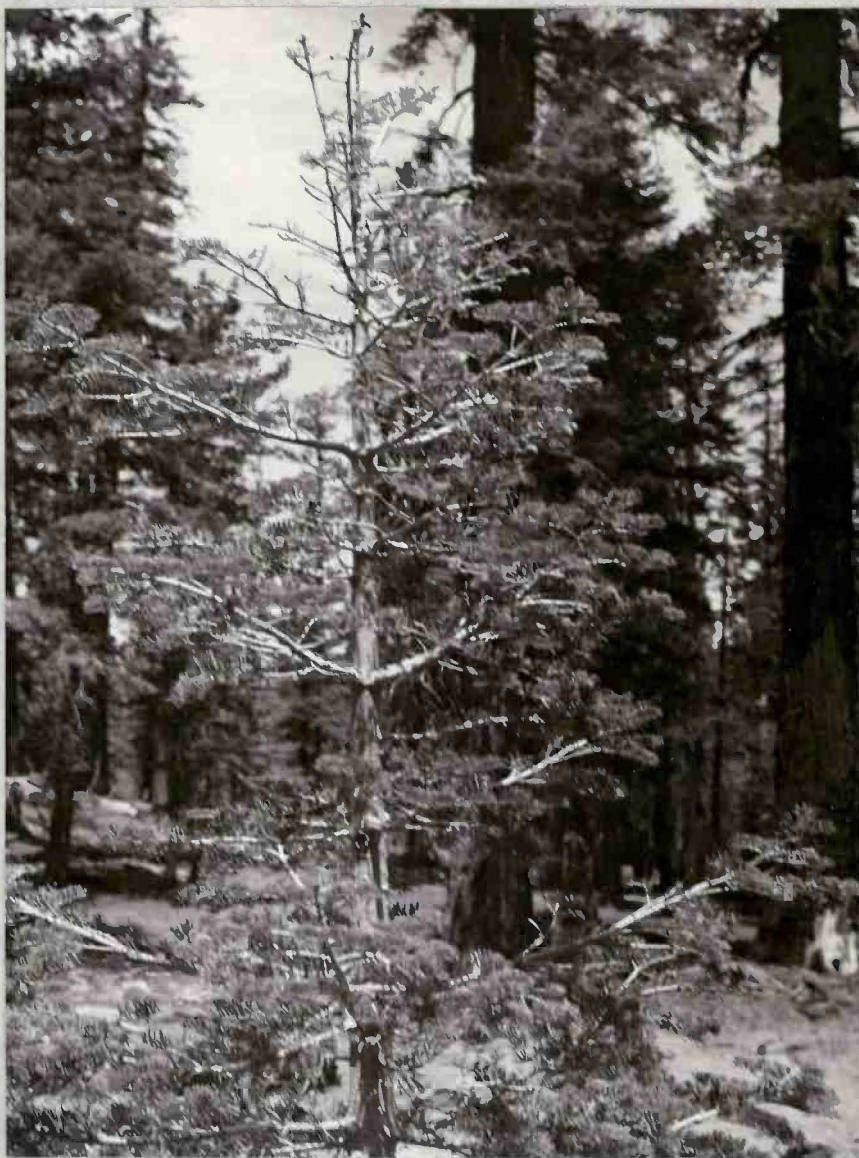
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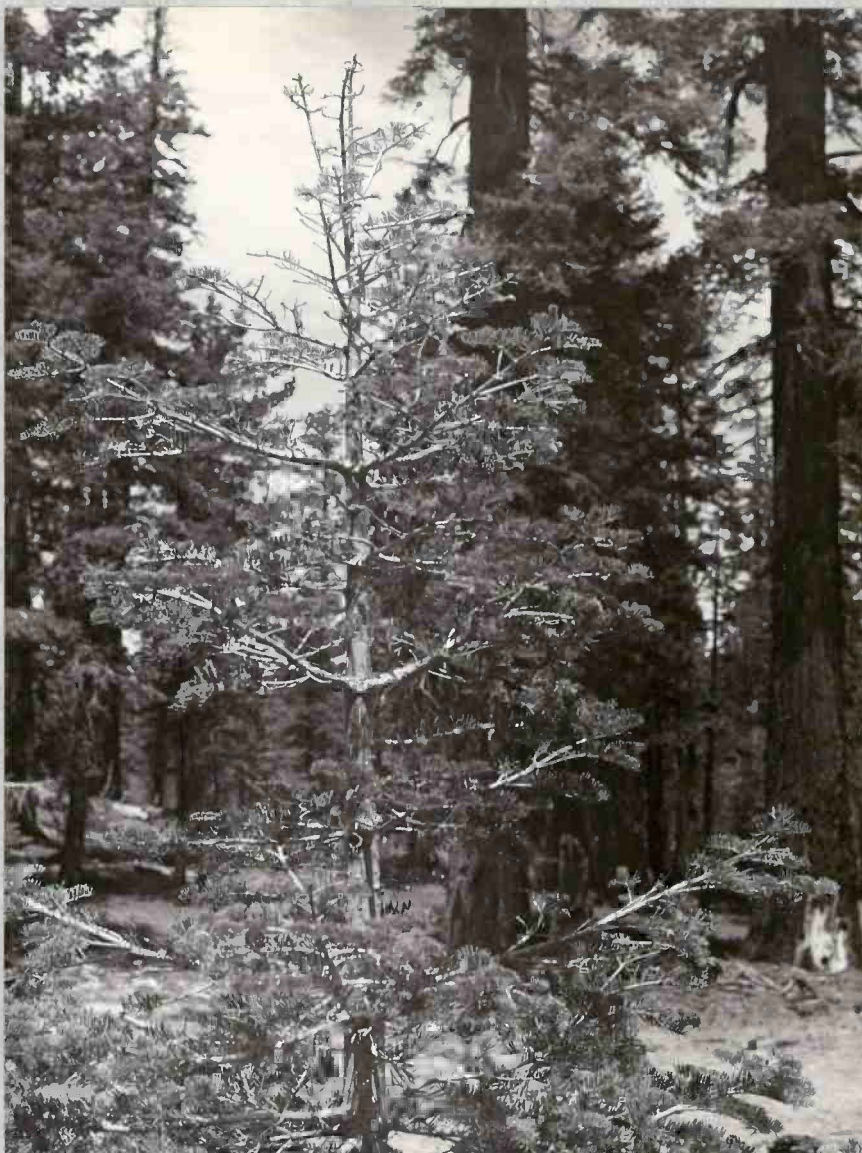
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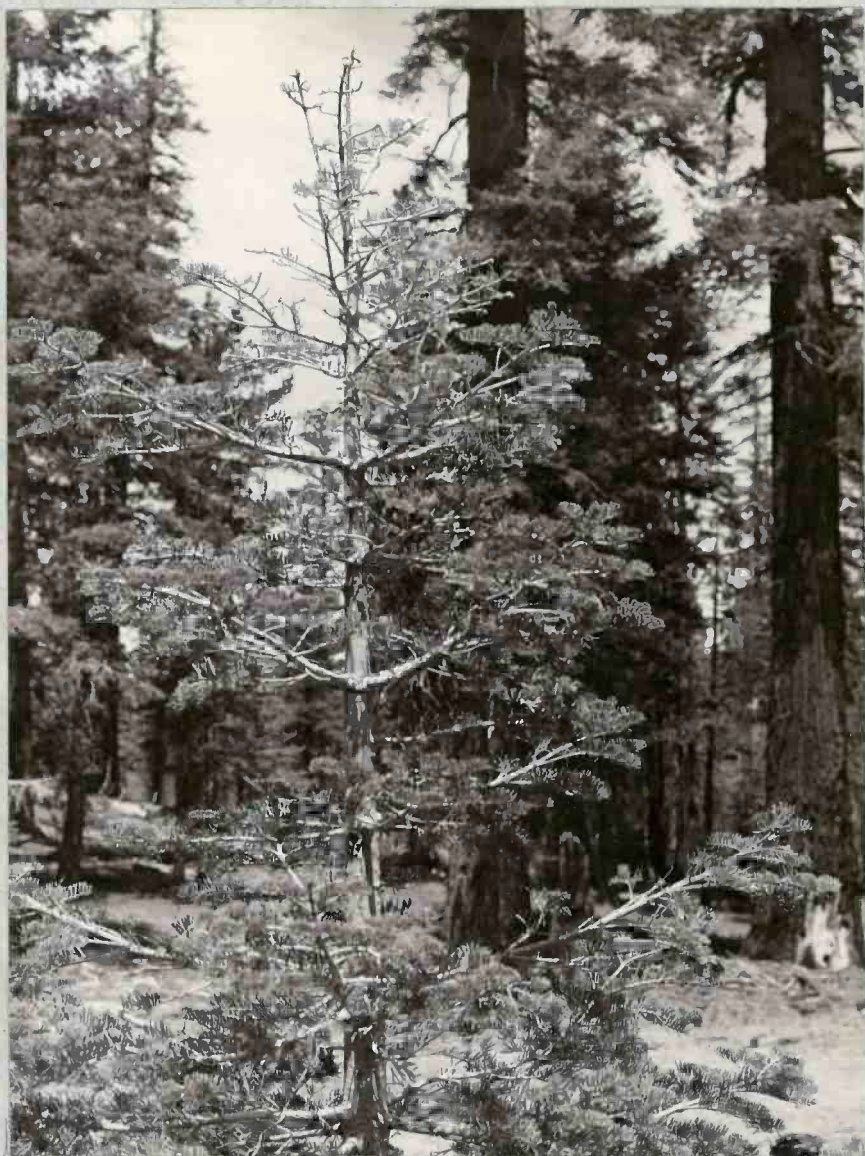
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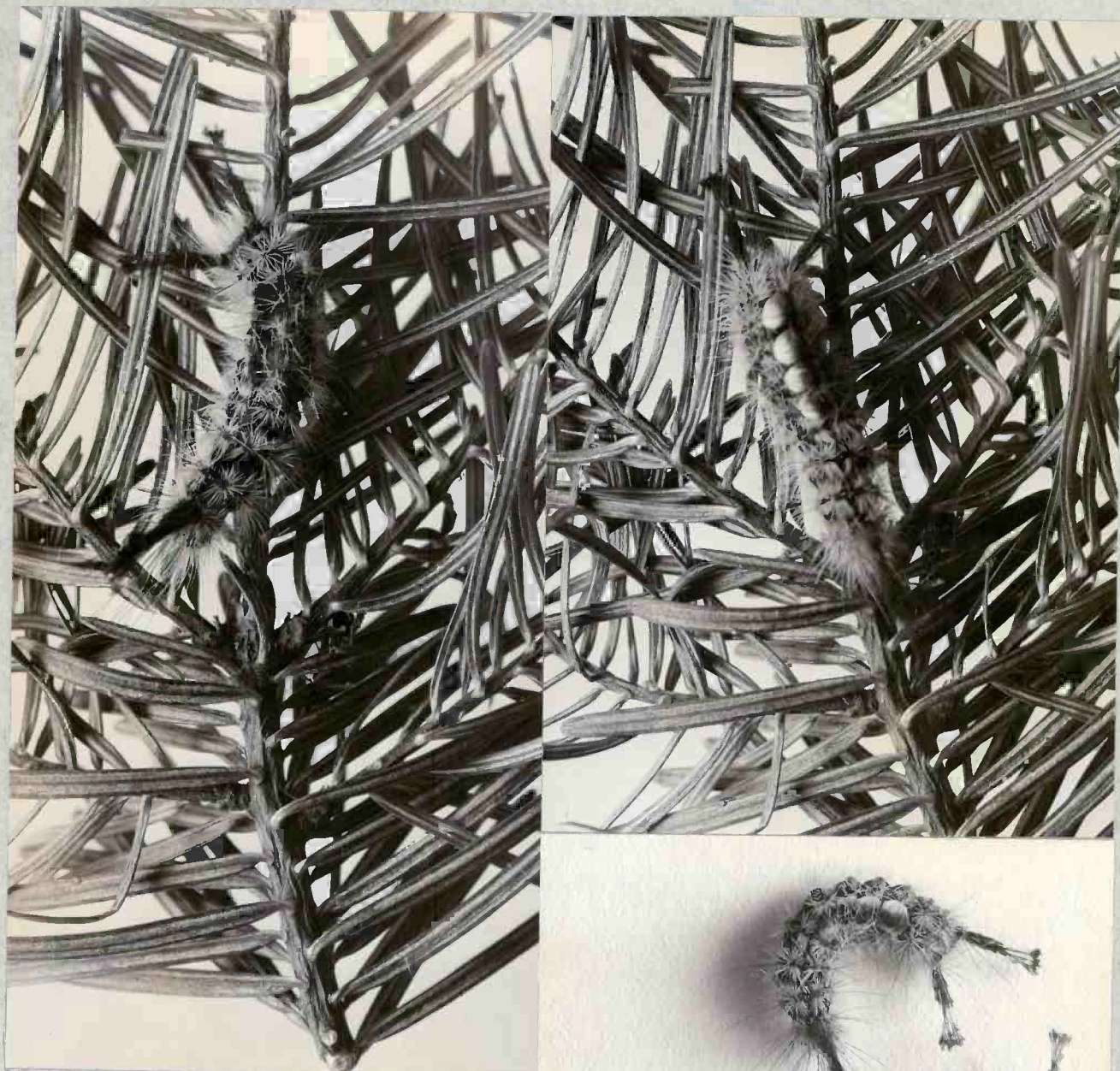
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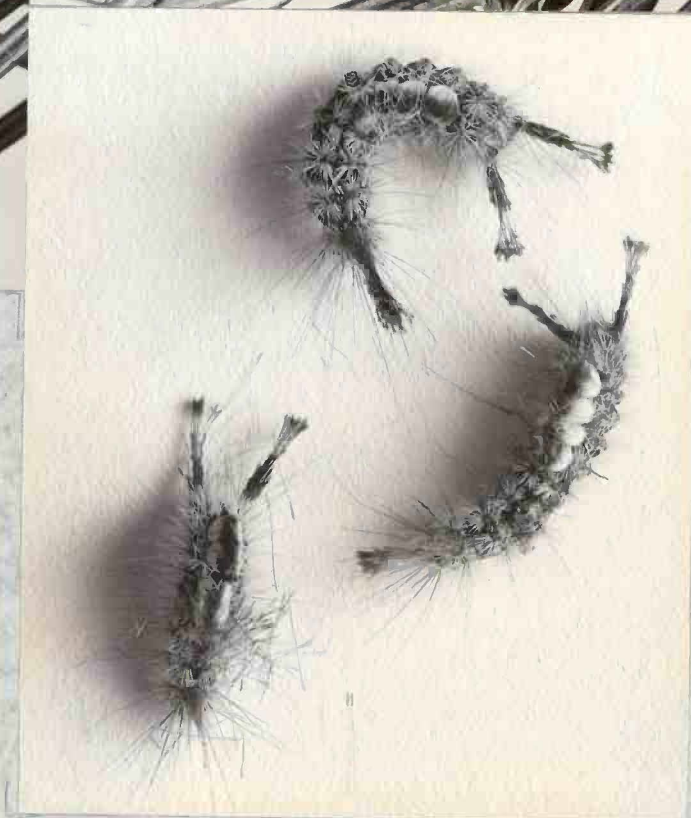
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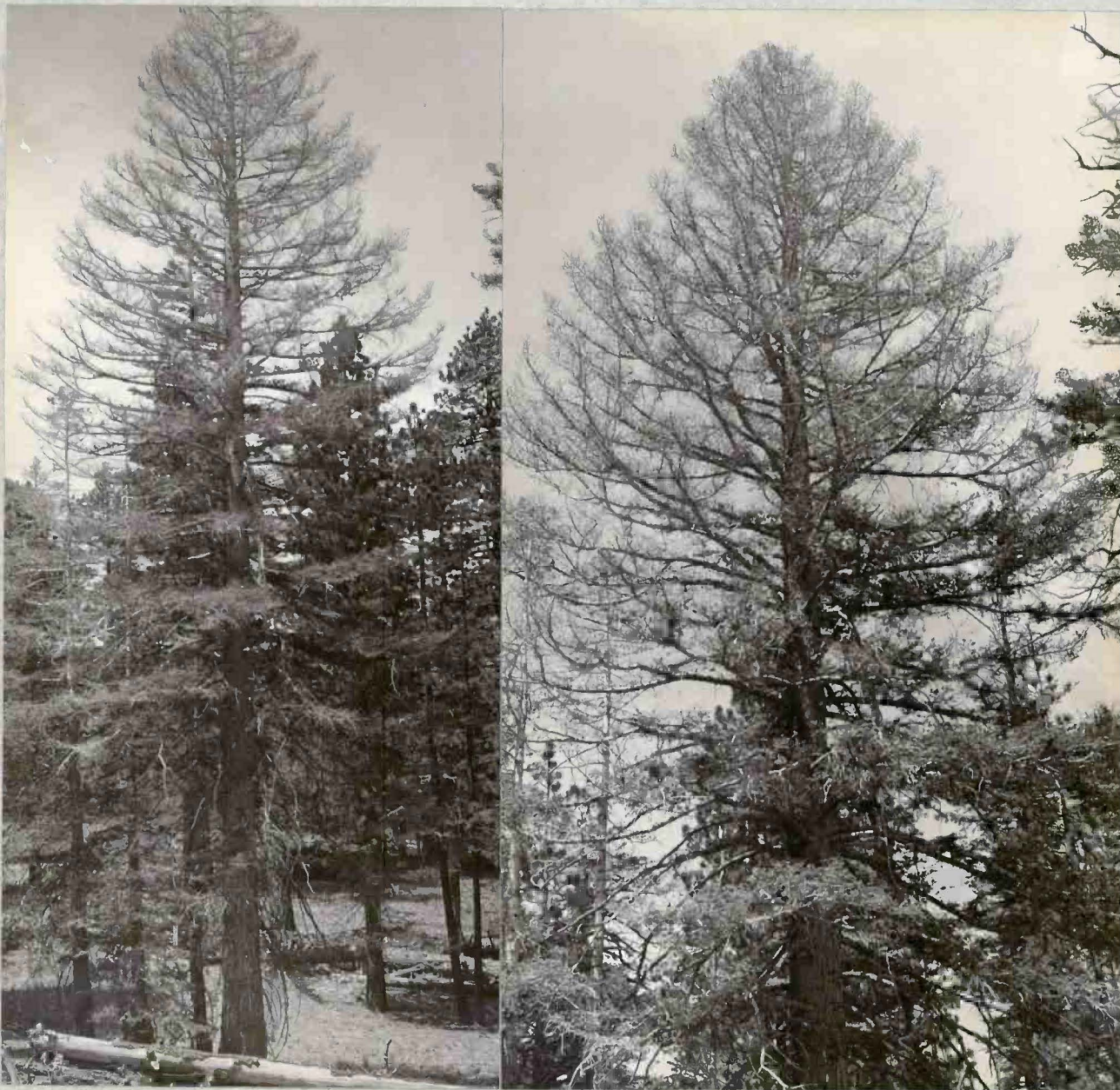


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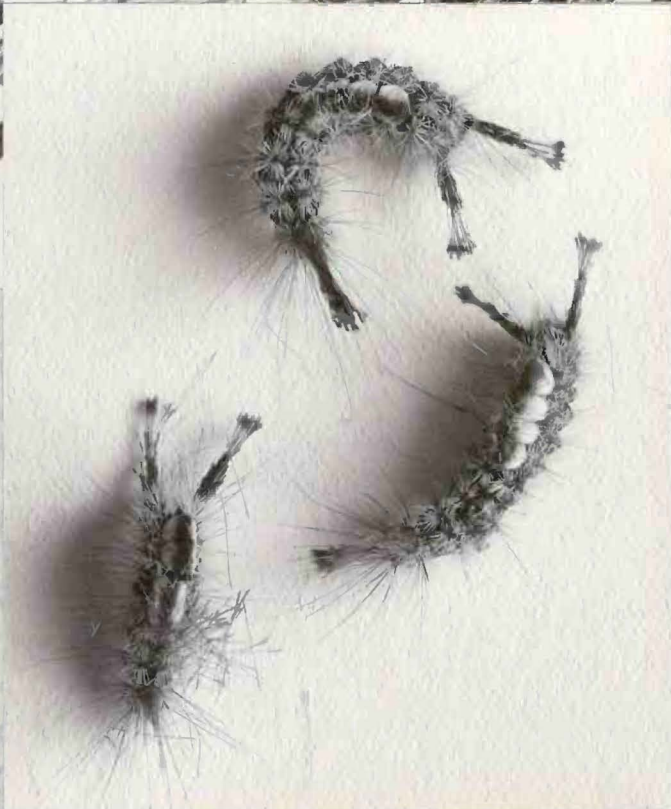
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larged about 2x.

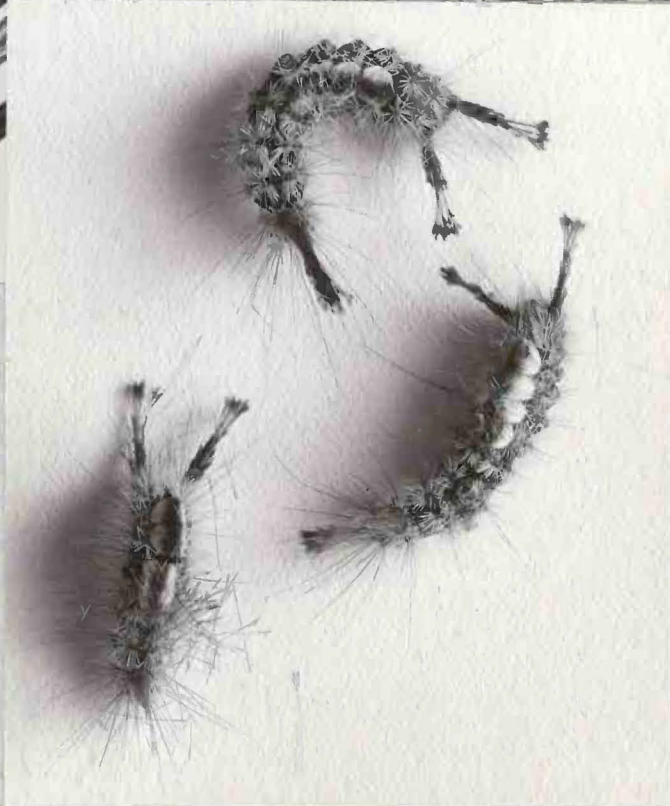


5937 - Full grown caterpillars of Osler's tussock moth. Caterpillars of the last instar just before pupation. Above: on white fir twig, and at right: detail of caterpillars on white card. Enlarged about 2X.



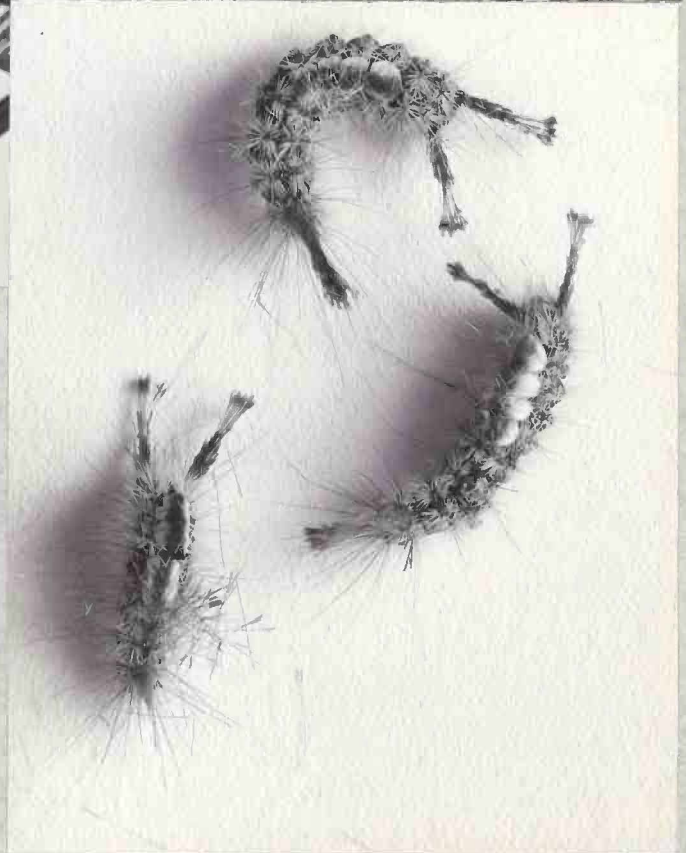


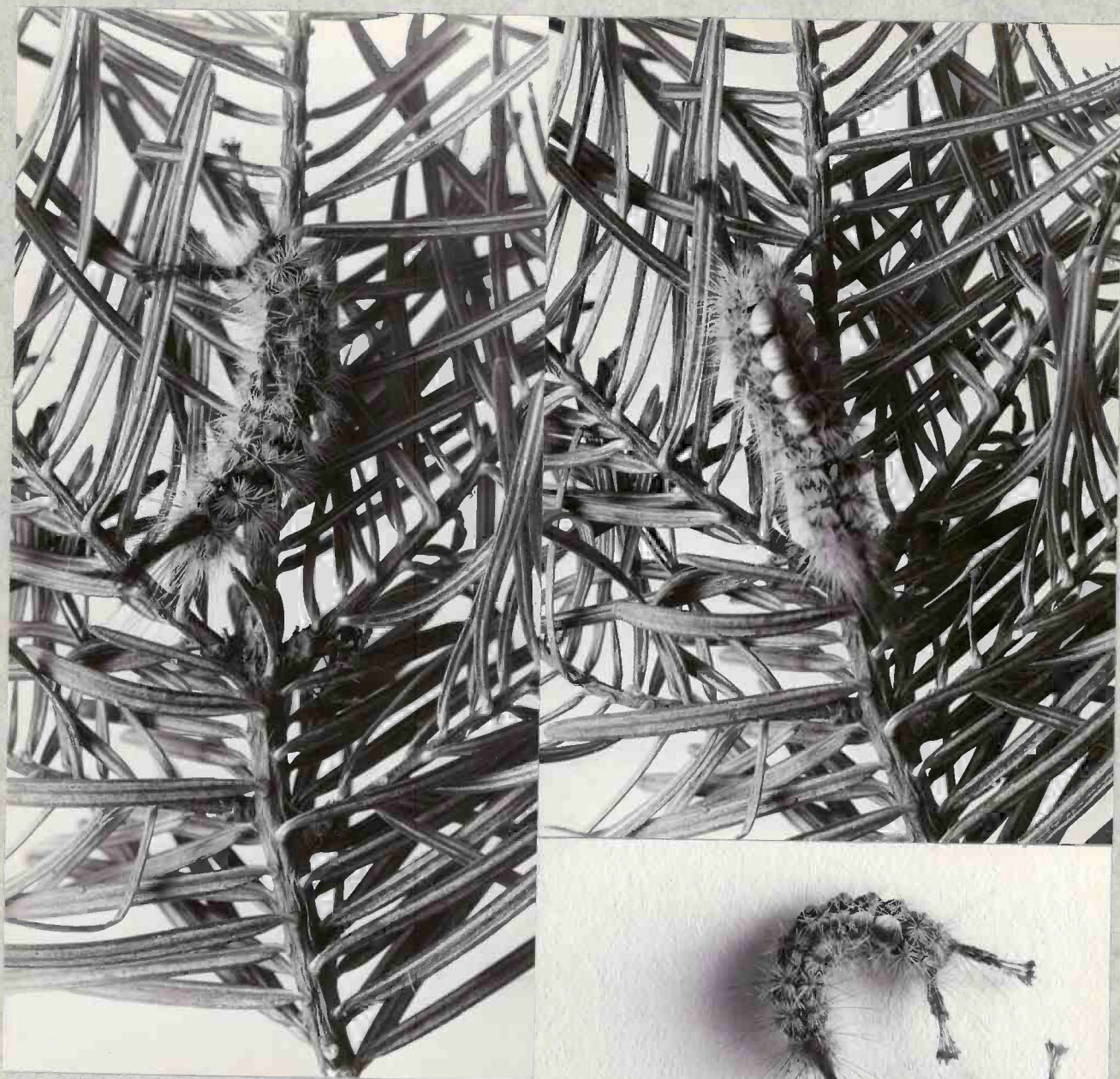
9937 - Full grown caterpillars of Osler's tussock moth. Caterpillars of the last instar just before pupation. Above: on white fir twig, and at right: detail of caterpillars on white card. Enlarged about 2X.



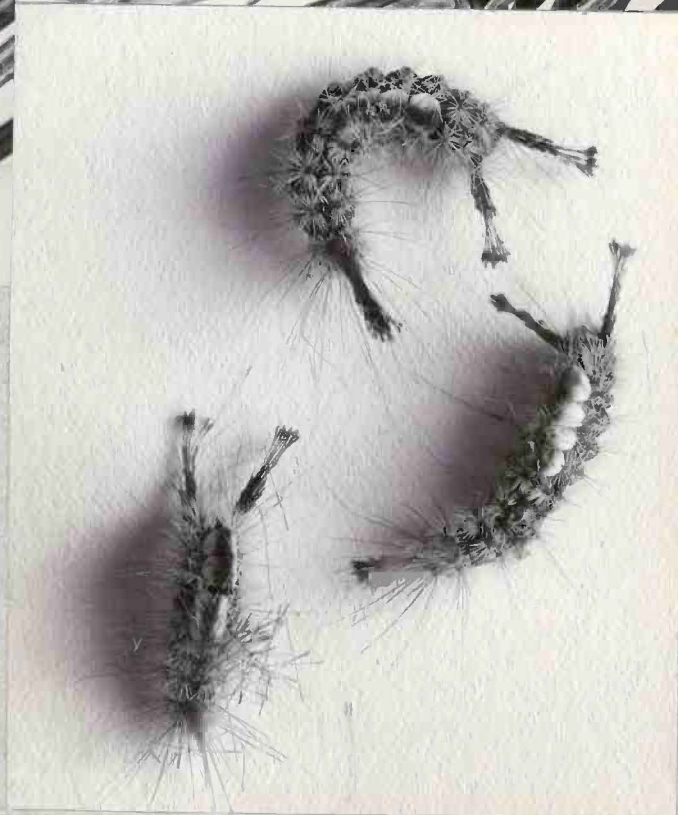


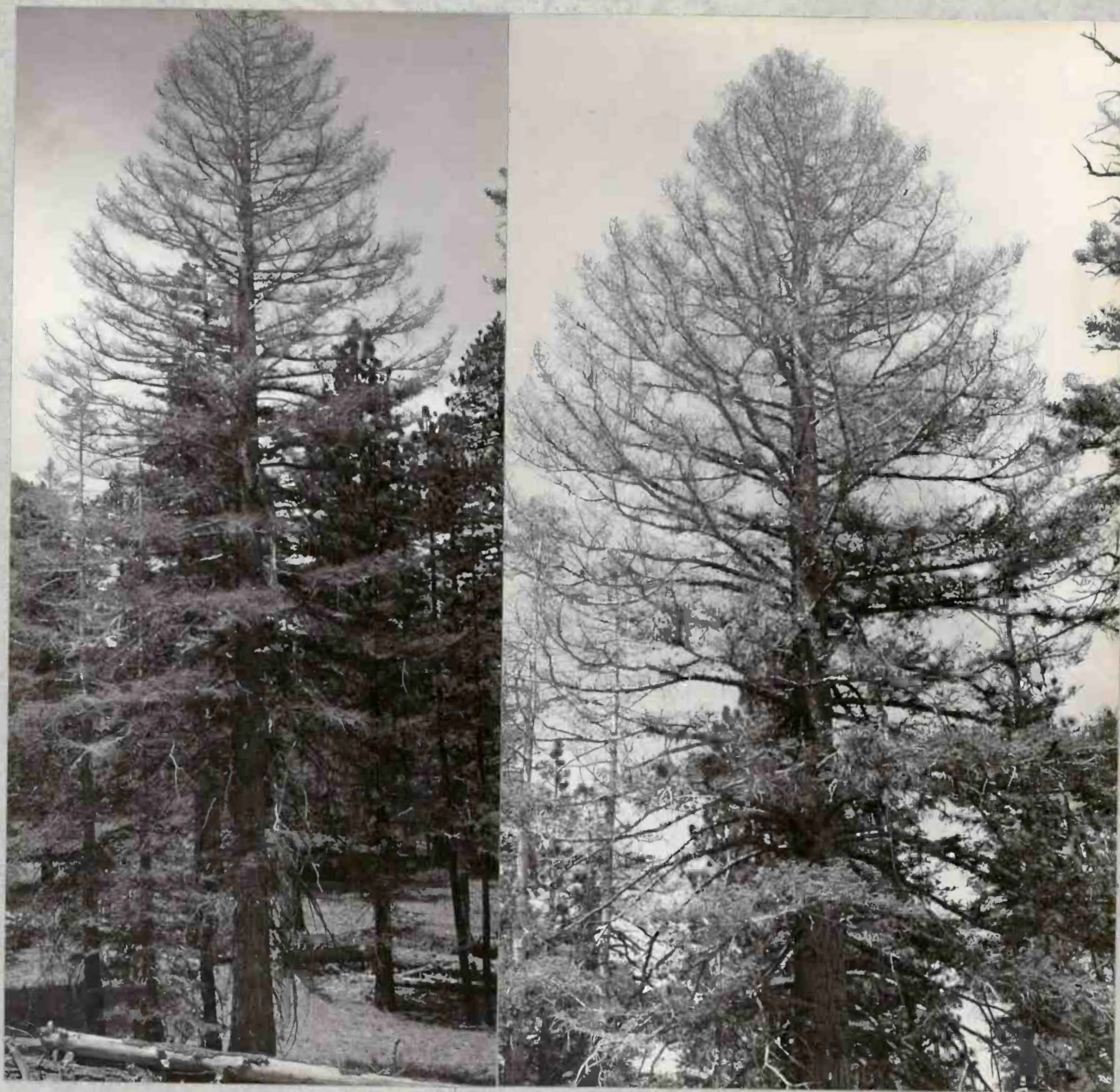
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9931B - 9931C - Severe defoliations of mature white fir characteristic of epidemic centers of infestation. Tree at left is completely stripped of needles and has small chance of recovery. Only the upper crown of the tree at the right is stripped. This tree may survive as a spike top.



9931D - Partial defoliation of the upper crown of a vigorous, middle aged, white fir tree. Such examples will recover if defoliation is not continued.

Charis Tussock Moth - *Homocampa osleri*

When this tussock moth develops infestations of epidemic proportions resultant defoliations are severe and often result in the death of the host. Generally its feeding is largely confined to the upper crown of attacked trees, but if the infestation continues for more than 2 years in the same area, lower foliage is taken as well. Usually when 30% to 50% of the crown complement is affected the tree dies as a direct result of defoliation. However, if it survives the end is a sawed and topped tree, greatly weakened and subject to attack by several other insects, principally bark beetles and wood borers, which while secondary in attack, completes the killing.

Infestations appear periodically. In the past periodicity of epidemics has been about 20 years. Subsidence is general in any one region and occurs so suddenly as the inception of epidemics. Parasites become numerous after epidemic conditions are sustained for 2 or 3 years, and are a prime factor in natural control. Wet diseases develop

after 3 or 4 years and rapidly decimate the population.

The foregoing remarks apply specifically to infestations in the Inyo-Mono region east of the Sierra Nevada Mountains.

Habit: Caterpillars are gregarious when newly hatched but soon disperse and feed singly. Tentacles are wingless and cannot fly. They do, however, crawl about considerably on all parts of the trees and have been observed migrating to other trees. Moths are winged and are strong fliers moving about in the forest to some distance beyond the home area. Mating occurs soon after the adults emerge from the cocoons; sometimes before they are dry. In the early stages of an epidemic feeding is largely confined to the upper crown. Later lower foliage is taken as well.

Caterpillars are heliotropic and move to the underside of the foliage during the midday period on sunny days. They also migrate from one tree to another by coming to the ground and crawling to other trees where they ascend by crawling up the trunk.

Hosts: In the eastside Sierra region, the principal and preferred host is white fir. Jeffrey pine is also taken when it occurs in an infested area but so far no epidemics have developed in pure stands of the pine. Red fir is not attacked although it grows in stands of white fir where epidemics have developed. Caterpillars can feed exclusively on either white fir or Jeffrey pine and complete their growth, pupating on the host tree feed upon! Tops of trees are attacked first, defoliation beginning at the top and working down with each successive generation. Trees of all sizes, from 3 ft. to the tallest, are taken indiscriminately.

Range: The range of the species during the recent epidemic extended from Convict Creek - Mammoth and Hat Creek - thru the Glass Creek area - Hess Hill, Big Springs, Reversed Creek Canyon - Mono Basin, Looking Canyon to Bridgeport Valley. North side Oundenburg Trak. It is probable that some infestation was present in all the East Side fir stands from Big Pine Creek north to the Warner Mountains.

Inception of epidemics: During the recent epidemic period areas of high concentration developed locally and without apparent connection or relation to others. No two areas coalesced, or was there any great spread from initial infested areas. The factors responsible for these conditions were not ascertained and nothing was learned regarding the inception of the epidemic. The females being without wings and therefore unable to fly very partially account for the stationary character of the epidemic areas.

Damage: The primary damage consists of the stripping of needles from attacked trees. This may be light to heavy, but in any case results in retarded growth, dying of terminals, or even death of the entire tree, the degree of injury depending directly upon the amount of foliage lost. The first heavy feeding in the recent epidemic occurred in 1932. A check plot located in the Hess Tree Area in 1938 gave the following data on damage to host. The plot contains 5 acres and 163 white fir trees above 4 inches in diameter that were living when the infestation first appeared. In recording the trees 5 classes were set up,

deposition was based on present of
crown deposited.

Class O - Trees not attached
Class I - $\frac{1}{4}$ of crown deposited 11%
Class II - $\frac{1}{2}$ of crown deposited 26%
Class III - $\frac{3}{4}$ of crown deposited 30%
Class IV - All of crown deposited 21%
All class IV trees were dead when started,
representing a primary loss of 21% of
the stand. Since there are additional 14
trees, one in class I, four in class II, and
nine in class III, four dead, showing
a total of 48 trees, or 30% of the stand
killed. The first number represents
dead attributable to the primary injury
alone, deposition. The latter to deposition
plus subsequent attack by other
injurious insects, scale, tree sp., bark beetles,
and wood boring larvae, etc.
Continued loss caused by these
secondary insects may go on for
a number of years until the
surviving trees regain their vigor,
and many in the end cause a
greater loss than incurred directly
from deposition.

90 Hrs
Died

18	0
42	2
49	8
21	43
34	100
164	

Host Injury:

Primary injury to the host results from defoliation. Check area sample in the Hess Hill Center shows that 89% of white fir was attacked, 55% were noticeably defoliated and 33% were completely defoliated. Severely defoliated trees usually die as a direct result of loss of needles.

Secondary injury and death results from attacks by *Scolytus* and *Ictropium* made on trees weakened by defoliation. At the close of the 1938 season 20% of the defoliated trees which had survived the primary injury had died from attacks of these beetles. Two bark beetles, *Scolytus ventralis* and *Scolytus subseres*, attacked the upper bole and terminals while the fir Carr beetle, *Ictropium abietis*, attacked the main boles.

Notes on the recent epidemic:

The recent infestation developed to epidemic proportions in 1931. It appeared simultaneously in several local areas in the region extending from Convict Lake north to Hell Gate Pass. These local centers varied in size from about 80 to 800 acres. They are sketched on the attached map and are designated by local names and may be identified by reading from south to north as: Hess Hill, Convict Lake, Mammoth Mt., Casa Diablo, Big Springs, Glass Creek, Round Creek, Le Vining, Lundy Canyon, Deverberg, Hell Gate.

Infestation reached the peak in 1936 and 1937. A decline began in late 1937 when a wet disease developed in the prepupal caterpillars during August and September. Count made on caterpillars selected at random on both foliage and tree trunks resulted in the following data: 100 Caterpillars on foliage showed 22 affected with witt. 100 Caterpillars on trunks. Crawling and quiet showed 27 limp with witt.

Length of full grown caterpillars ranged from 18 to 25 mm.
High winds blow caterpillars out of trees when they fall to the ground, usually

recognized. They occur often but
by crawling up the trunk.
The migration completely unknown
in 1938. The period 1931 to 1938 unknown
represent a period of 8 years duration
for this epidemic.
General: No writer or birds have
been observed feeding on the
caterpillars or pupae. The long toxic
hairs on the caterpillars are visible
with the microscope may give them
great protection from these enemies.
No parasites were reared directly from
the moth but larvae, Braconids,
and Ichneumonidae parasites were
observed on several occasions in
cigarotata. However, they were
not definitely connected up with the host.
West (Odykott), a disease which
develops often as migration from
new a few years, becomes widespread
and soon brings about complete
control by killing practically all caterpillars.
Dust from this disease does not
occur until the caterpillars are fully
grown.

Life History:

Adults: Adult moths emerge in late August and thru September. The males are winged and are strong fliers. The females are wingless but do considerable crawling about on the foliage. Mating may take place immediately after emergence and while the females are still wet or it may occur several hours or days later.

Eggs: The eggs are deposited in masses and are firmly attached to whatever support is selected. They are usually laid among abandoned cocoons on the twigs or on the bole of the tree. Egg masses have also been found on debris near the base of trees indicating that eggs may be laid in many situations. The incubation period is prolonged, lasting throughout the winter and spring months.

Larvae: Eggs hatch early in June to late June, usually about the time the new needle growth reaches the advanced stage. After the first moult they feed indiscriminately on the new growth as well as on needles of previous years. In newly





developed infestations, the Caterpillars select the upper crown and the first attacks are made on this part of the tree. Later, as the epidemic gains in intensity and as hordes of Caterpillars infest each tree in an invaded area, they take the needles lower down and eventually strip the entire tree. The feeding period extends normally from June 1-15 to August 15-20. The Caterpillars are clothed with long hairs which are grouped along median and lateral dorsal lines forming tufts or "tussocks", hence the common name. These long hairs are toxic and cause an irritating rash when they come in contact with the skin.

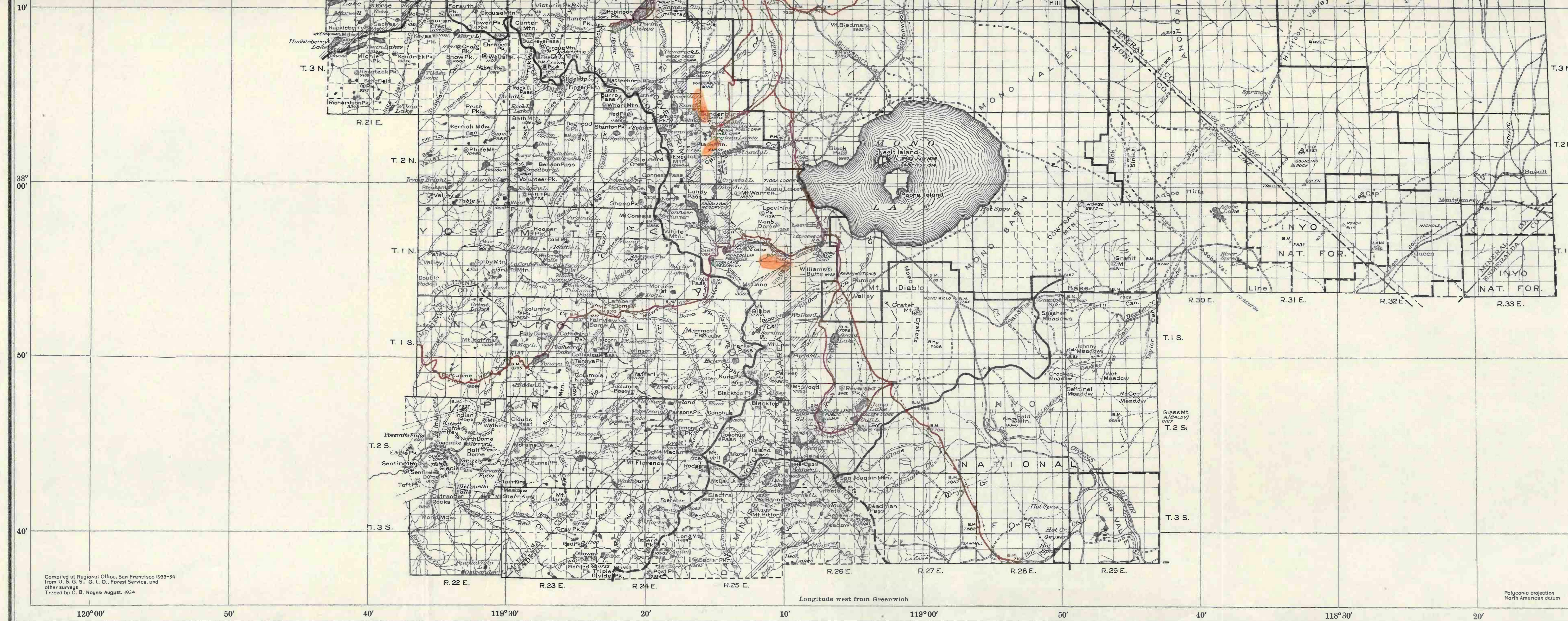
Pupae: Pupae are formed in cocoons which are spun up on the lower sides of branches, on the tips of secondary twigs, and sparingly on the lower trunks of trees. The cocoons are densely covered with body hairs from the Caterpillars.

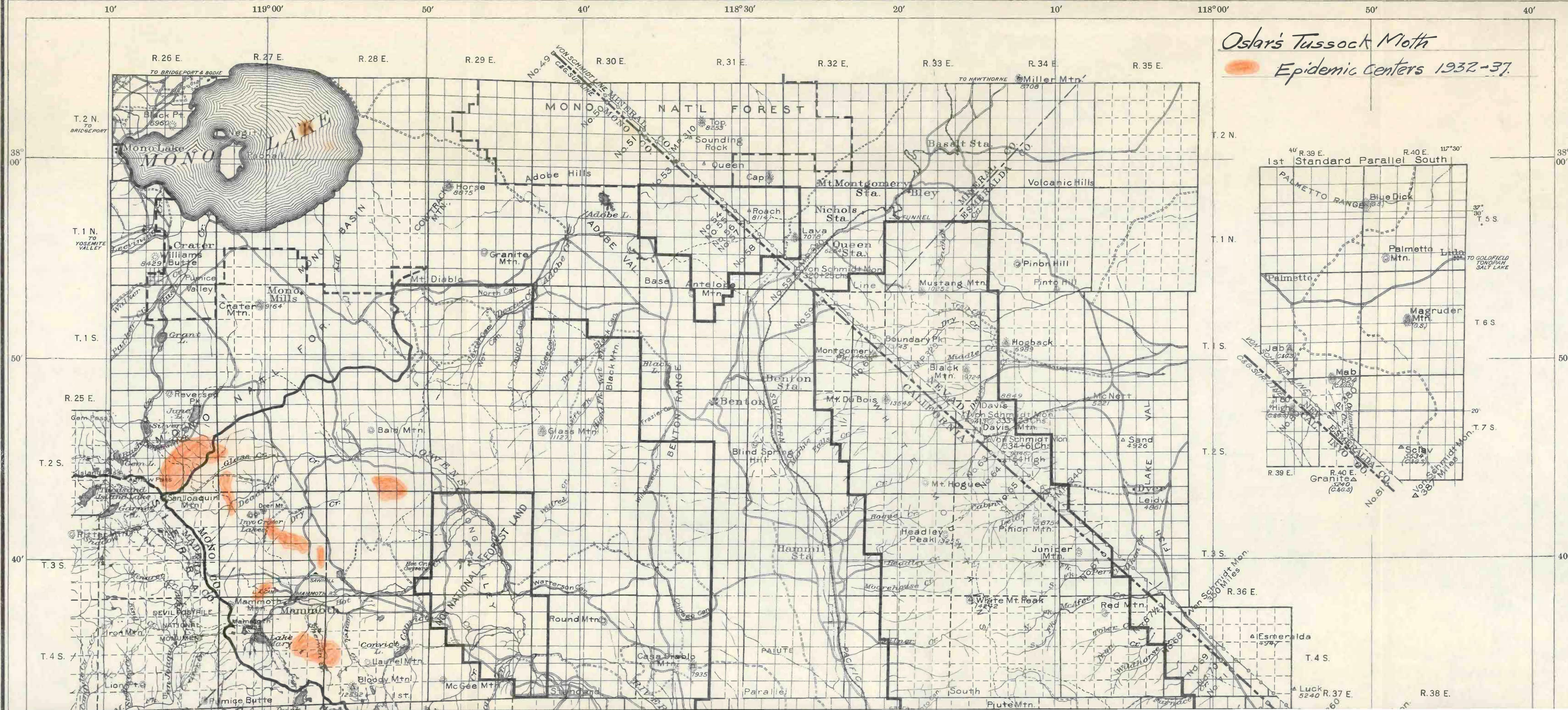
Incidentally these body hairs contain a toxic substance which causes extreme irritation to the skin and may protect the larvae and pupae

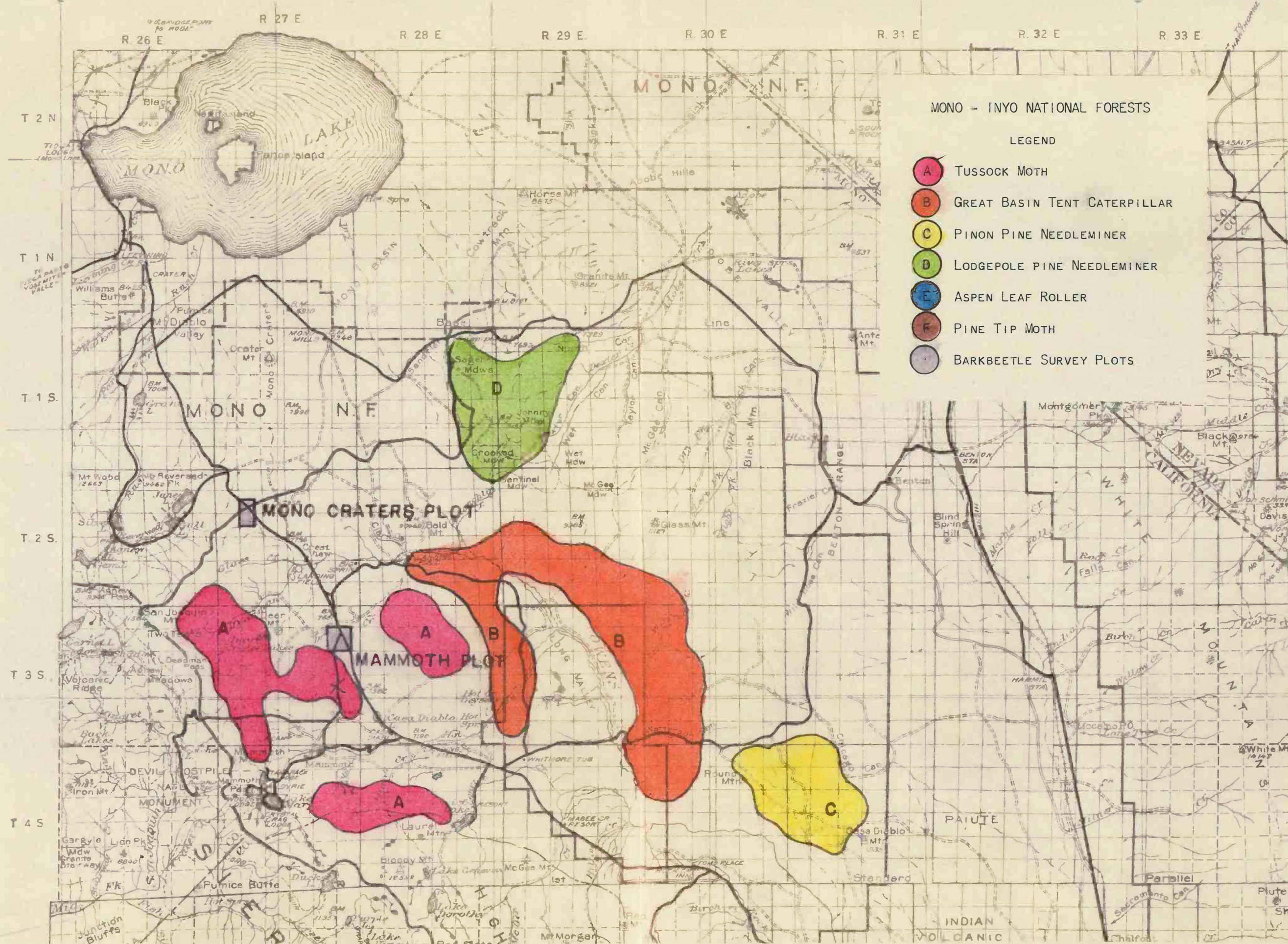
from being eaten by birds and rodents.
Cocoons usually occur in groups
and from 3 to 12 may be found matted
together in one mass. The pupal
period lasts from August 15 to Sept 20.

The species has a yearly life cycle
which may be diagrammed as follows:
The event dates given are approximate
and may vary somewhat from
year to year.

<u>Stage</u>	<u>Aug</u>	<u>Sept</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mch</u>	<u>Apr</u>	<u>May</u>	<u>June</u>	<u>July</u>
adults	<hr/>											
Eggs	<hr/>											
Larvae	<hr/>											
Pupae	<hr/>											







MONO - INYO NATIONAL FORESTS

LEGEND

- A TUSOCK MOTH
- B GREAT BASIN TENT CATERPILLAR
- C PINON PINE NEEDLEMINER
- D LODGEPOLE PINE NEEDLEMINER
- E ASPEN LEAF ROLLER
- F PINE TIP MOTH
- BARKBEETLE SURVEY PLOTS

